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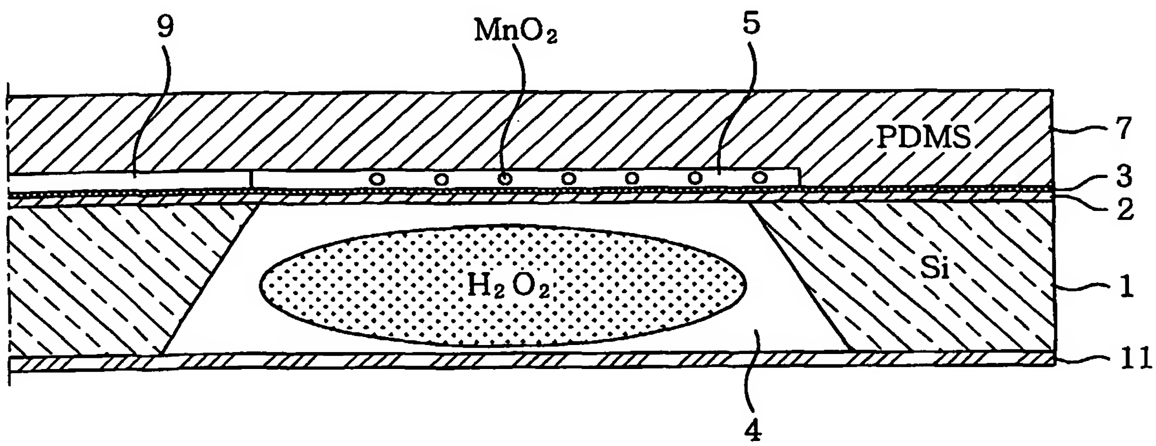
(54) Title: MICROPUMP AND MICRO-INCUBATOR UTILIZING GAS GENERATION AND PRODUCTION METHOD THEREOF



(57) Abstract: A micropump utilizing gas generation includes a silicon substrate having a reservoir for H_2O_2 solution formed therein, a SiO_2/Si_3N_4 film formed on the silicon substrate, and a PDMS combined on the SiO_2/Si_3N_4 film, wherein the PDMS has a reservoir for MnO_2, a sample reservoir connected to the reservoir through a conduit, a sample injection opening, and a minute channel. Further, a cell culture unit utilizing gas generation possesses a carbon dioxide supply including a glass substrate to secure a reservoir, a hot-wire formed inside the reservoir, a PDMS having the reservoir formed by combining the PDMS on the bottom surface and an air supply line connected to the reservoir though a conduit, a thin permeable PDMS film arranged on the PDMS, and a PDMS cover being combined on the PDMS film and having a channel through which a cell culture medium flows and a culture surface for a cell engraved therein.

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MICROPUMP AND MICRO-INCUBATOR UTILIZING GAS GENERATION AND PRODUCTION METHOD THEREOF

Field of the Invention

The present invention relates to a micropump and a cell culture unit for micro-structures including LOC; and, more particular, to a micropump and a cell culture unit utilizing gas generation and the production method thereof to generate a small amount of gas through a series of processes including MEMS ("Micro-Electro-Mechanical Systems") process for use in subsequent chemical reactions or additional processes.

Background of the Invention

LOC ("Lab-on-a-chip") is a new small-sized analytic device designed to perform a rapid and efficient automatic analysis by integrating a series of devices for analyzing specimen such as devices for specimen preparation, reaction, separation and detection onto chips made of glass, plastic or silicon having dimensions of centimeters, taking advantage of micromachining technology such as photolithograph and etching. μ-TAS ("micro total analysis systems") is a typical application of LOC.

Because separation analysis using LOC requires only an infinitesimal amount of specimen, its application is advantageous in medical diagnostic field and biological application where a large amount of specimen is difficult to obtain. Though it is currently being used in analyses of *in vitro* materials for such use as separation of amino acids and peptides, DNA sequencing, and immunoassay, its application is being expended. Among other fields, noticeable application is made in the following fields: environmental pollutant analysis requiring real-time field

analysis; new generational diagnosis and measurement requiring a portable micro-laboratory to ascertain a result at the site; and new drug research requiring fast analyses of multiple samples.

For operation of the LOC, however, an external driving power is required to convey the materials into the chips. Methods of conveying the materials developed up to now include an electrokinetic method using the principles of electro-osmosis and electrophoresis, or using pumps such as micro-motors. The aforementioned conventional conveying methods necessarily require continuous external power supplies. This results in a shortcoming that the entire chip size has to be increased or an additional equipment must be accompanied. Accordingly, for commercialization and field applications of LOC, developments of small-sized power supplies and pumps or its substitutes are required.

Further, for the up-to-date technology of LOC, i.e., a cell chip, to evolve into a small-sized portable cell culture unit, control of temperature and pH is essential. The temperature control can be accomplished by using fine hot-wires. The pH control of a cell culture medium, on the other hand, is accomplished by supplying carbon dioxide. Therefore, continuous supply of carbon dioxide is necessary, resulting in a shortcoming that conventional huge cell culture units must inevitably accompany a compressed carbon dioxide tank weighing tens of kilograms. Consequently, before a small-sized portable cell culture unit can be developed, a small-sized carbon dioxide supply needs to be developed.

Summary of the Invention

It is, therefore, an object of the present invention to provide a micropump including: a silicon substrate having a reservoir for H_2O_2 solution formed therein; a SiO_2/Si_3N_4

film formed on the silicon substrate; and a PDMS combined on the SiO_2/Si_3N_4 film, wherein the PDMS has a reservoir for MnO_2, a sample reservoir connected to the reservoir through a conduit, a sample injection opening, and a minute channel.

It is, therefore, another object of the present invention to provide a cell culture unit possessing carbon dioxide supply including: a glass substrate to secure a reservoir; a hot-wire formed at the bottom of the reservoir; a PDMS having the reservoir formed by combining the PDMS on the bottom surface and an air supply line connected to the reservoir through a conduit; a thin permeable PDMS film arranged on the PDMS, and a PDMS cover being combined on the PDMS film and having a channel through which a cell culture medium flows and a culture surface for a cell engraved therein.

Brief Description of Drawings

Fig. 1 is a cross-sectional perspective view of a micropump using gas generation in accordance with a first preferred embodiment of the present invention;

Fig. 2 is a cross-sectional view taken along line A-A' of Fig. 1 in accordance with the first preferred embodiment of the present invention;

Figs. 3A to 3F illustrate a procedure of producing the micropump which uses gas generation in accordance with the first preferred embodiment of the present invention;

Fig. 4 is a cross-sectional perspective view of a micropump which uses gas generation in accordance with a second preferred embodiment of the present invention;

Fig. 5 is a cross-sectional view taken along line B-B' of Fig. 4 in accordance with the second preferred embodiment of the present invention;

Figs. 6A to 6E illustrate a procedure of producing the micropump which uses gas generation in accordance with the

second preferred embodiment of the present invention;

Fig. 7 is a cross-sectional perspective view of a micropump utilizing gas generation in accordance with a third preferred embodiment of the present invention;

Fig. 8 is a cross-sectional view taken along line C-C′ of Fig. 7 in accordance with the third preferred embodiment of the present invention;

Fig. 9 is a cross-sectional perspective view of a micropump utilizing gas generation in accordance with a fourth preferred embodiment of the present invention;

Fig. 10 is a cross-sectional view taken along line D-D′ of Fig. 9 in accordance with the fourth preferred embodiment of the present invention;

Fig. 11 is an upper cross-sectional perspective view of a cell culture unit using gas generation in accordance with a fifth preferred embodiment of the present invention;

Fig. 12 is a lower cross-sectional perspective view of a cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention;

Fig. 13 is a cross-sectional view taken along line E-E′ of Fig. 11 in accordance with the fifth preferred embodiment of the present invention;

Fig. 14 is a schematic drawing showing an air supply line of a cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention; and

Fig. 15 is a schematic drawing showing a media-line of a cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiments

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

First preferred embodiment

Figs. 1 and 2, respectively, show a cross-sectional perspective view of a micropump using oxygen generation which separates H_2O_2 solution and MnO_2 by a SiO_2/Si_3N_4 film and a cross-sectional view taken along line A-A' of Fig. 1 in accordance with the present invention.

As shown in Figs. 1 and 2, a micropump using gas generation in accordance with the first preferred embodiment of the present invention reserves a reservoir for H_2O_2 solution 4 in a silicon substrate 1 which has a SiO_2/Si_3N_4 film 2 and 3 formed thereon. A PDMS ("polydimethyl siloxane", a kind of silicon rubber) 7 covers the assembly. The PDMS 7 has a reservoir for MnO_2 5, a minute channel 6, a sample reservoir 8, a conduit 9, a sample injection opening 10, and the like formed thereon. When a slight physical impact or pressure is transmitted to the PDMS 7 from outside, the SiO_2/Si_3N_4 films 2 and 3 break into pieces simultaneously, mixing the upper MnO_2 with the lower H_2O_2 solution. Oxygen, generated in such a manner, is discharged through the minute channel 6 for the use in the following reactions or pushes a liquid sample which lies ahead.

As shown in Fig. 1, the conduit 9 is formed to connect the reservoirs for H_2O_2 solution and MnO_2 4 and 5 with the sample reservoir 8. The sample injection opening 10 is formed at an end of the sample reservoir 8 to which a sample is injected. The minute channel 6 is formed behind the sample reservoir 8.

Figs. 3A to 3F illustrate a procedure for producing the micropump using gas generation in accordance with the first preferred embodiment of the present invention. Specifically, Figs. 3A to 3C show processes to form structures such as the MnO_2 reservoir 5, the minute channel 6, the sample reservoir 8, the conduit 9 and the sample injection opening 10 in a PDMS. Figs. 3D to 3F show

processes of forming the H_2O_2 solution reservoir 4 in a silicon substrate and covering the silicon substrate with the PDMS in Fig. 3C.

A procedure in accordance with Figs. 3A to 3F proceeds in the following sequence:

(a) As shown in Fig. 3A, a layer with thickness of about 65 μm is formed on a silicon substrate 12 by spin coating and patterning a negative photoresist SU-8.

(b) As shown in Fig. 3B, the space for the MnO_2 reservoir is formed on the assembly of (a) by stacking layers. This is achieved by repeating the process of (a) using SU-8.

(c) As shown in Fig. 3C, a PDMS is poured and hardened on the silicon substrate 12 and patterned SU-8 layer 13.

(d) As shown in Fig. 3D, a SiO_2 film 2 and a Si_3N_4 film 3 are formed sequentially on both sides of the silicon substrate 1.

(e) As shown in Fig. 3E, a HMDS ("hexamethyldisilazane") and a positive photoresist AZ 9260 are spin coated sequentially on the bottom surface of the silicon substrate having the SiO_2/Si_3N_4 film 2 and 3 formed thereon. The portion to be etched is exposed to ultraviolet rays using a mask and developed. Subsequently, the Si_3N_4 film is removed by RIE ("reactive ion etching") method and the SiO_2 film is removed by using BHF ("buffered HF") solution. After the H_2O_2 solution reservoir 4 is secured by etching the silicon substrate with silicon etching solution TMAH ("tetramethylammonium hydroxide"), a vinyl film or a glass substrate 11 is secured thereto.

(f) As shown in Fig. 3F, a micropump using gas generation is completed by removing the PDMS of (c) from the silicon substrate and SU-8 pattern and covering it on the substrate of (e).

Second preferred embodiment

Figs. 4 and 5 show a cross-sectional perspective view of a micropump using oxygen generation to which a structure to isolate H_2O_2 solution from MnO_2 using a paraffin is applied and a cross-sectional view taken along line B-B′ of Fig. 4 in accordance with the second preferred embodiment of the present invention.

According to the second preferred embodiment of the present invention, oxygen gas is generated when MnO_2 is discharged into H_2O_2 solution by melting paraffin using a hot-wire to which an external electric current is applied. Thus generated oxygen gas pushes and moves liquid in a minute channel. Once the MnO_2 is discharged into the H_2O_2 solution, the MnO_2 remains in the H_2O_2 solution and continues the reaction even after the electric current is shut off.

As shown in Figs. 4 and 5, a micropump using gas generation in accordance with the second preferred embodiment of the present invention secures a reservoir for H_2O_2 solution 24 on a glass substrate 21, the reservoir 24 having a hot-wire 23 arranged in a row or ruggedly therein. Paraffin mixed with MnO_2 powder 25 is formed on the hot-wire 23. A PDMS 27 which shapes the reservoir 24 and includes a minute channel 26, a sample reservoir 28, a conduit 29 and injection openings 30 formed therein covers the glass substrate 21.

As shown in Fig. 4, the conduit 29 is formed to connect the reservoir 24 with the sample reservoir 28. At each ends of the H_2O_2 solution reservoir 24 and the sample reservoir 28, respective injection openings 30 are formed to inject H_2O_2 and a sample thereto. The minute channel 26 is formed behind the sample reservoir 28. Total size of the micropump using gas generation in accordance with the second preferred embodiment is approximately 2 cm x 1 cm (width x length).

Figs. 6A to 6E show a procedure for producing the micropump using oxygen generation in which H_2O_2 solution and MnO_2 is separated by paraffin in accordance with the second preferred embodiment of the present invention.

The procedure in accordance with Figs. 6A to 6E proceeds in the following sequence:

(a) As shown in Fig. 6A, an aluminum layer of 0.2 ㎛ thickness is formed by thermal evaporation, forming a hot-wire on the glass substrate 21. The hot-wire is formed in an area of about 2 ㎜ x 2 ㎜ with a line width of 30 ㎛.

(b) As shown in Fig. 6B, after spin coating an HMDS and a photoresist AZ 5214 sequentially, ultraviolet exposure is performed using a hot-wire pattern mask. After etching aluminum portions which do not correspond to the hot-wire, the photoresist is removed by acetone.

(c) As shown in Fig. 6C, a PDMS is bonded to form a reservoir for H_2O_2 solution and MnO_2.

(d) As shown in Fig. 6D, after melting paraffin and mixing with MnO_2 powder, the layer 25 is formed by injecting the paraffin of about 2 ㎕ into the reservoir.

(e) As shown in Fig. 6E, an oxygen generator is completed by covering the assembly of (d) with a PDMS 27 having structures such as a minute channel formed thereon and injecting about 5 ㎕ of 30%(w/w) H_2O_2 solution.

Third preferred embodiment

Figs. 7 and 8 show a cross-sectional perspective view of a micropump utilizing carbon dioxide generation which employs $NaHCO_3$ and a cross-sectional view taken along line C-C′ of Fig. 7 in accordance with the third preferred embodiment of the present invention.

According to the third preferred embodiment of the present invention, when $NaHCO_3$ is heated by a minute wire to which an external electric current is applied, the $NaHCO_3$ is

decomposed into Na_2CO_3, water and carbon dioxide according to the following chemical formula:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

Thus generated carbon dioxide pushes and moves fluid in a reservoir or a minute channel.

As shown in Figs. 7 and 8, a micropump using gas generation in accordance with the third preferred embodiment of the present invention includes a minute hot-wire 33 formed on a glass substrate 31 using a metal film such as an aluminum and preserves a reservoir for $NaHCO_3$ 34 using a PDMS. After filling $NaHCO_3$ into the reservoir 34, the glass substrate 31 is covered with a PDMS 37 on which a minute channel 36, a sample reservoir 38, a conduit 39 and injection openings 40 are formed.

A procedure for producing the micropump using carbon dioxide generation which employs $NaHCO_3$ in accordance with the third preferred embodiment of the present invention is identical to that of the micropump using oxygen generation to which a structure to isolate H_2O_2 solution from MnO_2 using paraffin is applied in accordance with the second preferred embodiment as shown in Figs. 6A to 6E wherein the only differences are that the process to form a paraffin layer mixed with MnO_2 powder 25 is omitted and that $NaHCO_3$ is injected instead of H_2O_2 solution.

Forth preferred embodiment

Fig. 9 shows a cross-sectional perspective view of a micropump utilizing carbon dioxide generation which employs a minute water droplet and a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$. Fig. 10 shows a cross-sectional view taken along line D-D′ of Fig. 9 in accordance with the fourth preferred embodiment of the present invention.

According to the forth preferred embodiment of the present invention, although a mixture of $NaHCO_3$ and

$HOC(COOH)(CH_2COOH)_2$ is stable in itself, $HOC(COOH)(CH_2COOH)_2$ reacts with $NaHCO_3$ to generate $HOC(COOH)(CH_2COONa)_2$, water and carbon dioxide according to the following chemical formula, in which case $HOC(COOH)(CH_2COOH)_2$ becomes an aqueous solution by adding water thereto.

$$3NaHCO_3(s) + HOC(COOH)(CH_2COOH)_2(s) \rightarrow HOC(COOH)(CH_2COONa)_2(s) + 3H_2O(l) + 3CO_2(g)$$

Thus generated carbon dioxide pushes and moves fluid in a reservoir or a minute channel.

As shown in Figs. 9 and 10, a micropump using gas generation in accordance with the fourth preferred embodiment of the present invention includes a minute hot-wire 43 formed on a glass substrate 41. The minute hot-wire 43 is composed of a metal film made of such material as aluminum. A reservoir 44 for a water droplet and a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$ is reserved by using a PDMS. After arranging a water droplet enveloped in a Parafilm (manufacturer: Pechiney Plastic Packaging, Chicago, a waterproof and dampproof film which melts easily when heat is applied) 45 on the hot-wire 43 and adding a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$, the glass substrate 41 is covered with a PDMS 47 on which a minute channel 46, a sample reservoir 48, a conduit 49 and injection openings 50 are formed. When the minute hot-wire 43 are heated, the Parafilm melts and the water droplet 45 bursts, discharging water. Subsequently, reaction between $HOC(COOH)(CH_2COOH)_2$ and $NaHCO_3$ starts and carbon dioxide occurs.

A procedure for producing the micropump using carbon dioxide generation which employs a water droplet and a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$ in accordance with the fourth preferred embodiment of the present invention is identical to that of the micropump using oxygen generation to which a structure to isolate H_2O_2 solution from MnO_2 using paraffin is applied in accordance with the second preferred embodiment as shown in Figs. 6A to 6E wherein the only

differences are that a water droplet 45 is arranged instead of the process to form a paraffin layer mixed with MnO_2 powder 25 and that a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$ is injected instead of H_2O_2 solution.

Fifth preferred embodiment

Figs. 11 to 13 show an upper and a lower cross-sectional perspective views of a cell culture unit possessing a carbon dioxide supply and a cross-sectional view taken along line E-E′ of Fig. 11 in accordance with the fifth preferred embodiment of the present invention.

According to the fifth preferred embodiment of the present invention, carbon dioxide generated by thermal decomposition of $NaHCO_3$, flowing through an air supply line (minute channel) 56, permeates through a thin PDMS film 58 formed on the air supply line. Thereafter, the carbon dioxide is to a cell culture medium laid on the PDMS film 58, which allows pH to be controlled.

As shown in Figs. 11 to 13, a cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention includes a minute hot-wire 53 formed on a glass substrate 51. The hot-wire 53 is composed of metal film made of such material as aluminum. A reservoir for $NaHCO_3$ 54 is reserved by using a PDMS. After setting a PDMS 57 on which an air supply line 56 is formed, $NaHCO_3$ is injected. A small-sized cell culture unit is completed by covering it with a PDMS cover 59 on which a media-line is engraved after setting of a thin permeable PDMS film 58. A cell culture medium and cells are injected into the completed small-sized cell culture unit through a media inlet. Then carbon dioxide is supplied by decomposing $NaHCO_3$ using a minute hot-wire to which an electric current is applied. At this time, the amount of the supplied carbon dioxide can be controlled by adjusting the electric current

applied to the minute hot-wire.

A procedure for producing a small-sized cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention proceeds in the following sequence:

(a) An aluminum layer of 0.2 μm thickness is formed on a glass substrate 51 by thermal evaporation.

(b) After spin coating an HMDS and a photoresist AZ 5214 sequentially, an ultraviolet exposure is performed using a hot-wire pattern mask. After etching aluminum portions other than a hot-wire 53, the photoresist is removed by acetone.

(c) A PDMS is bonded to secure a reservoir for $NaHCO_3$ 54.

(d) An embossing of an air supply line 56 frame having the shape shown in Fig. 14 is formed by performing ultraviolet exposure and development after SU-8 is spin coated on a wafer.

(e) A PDMS 57 in which the air supply line 56 is engraved is produced by pouring and hardening a PDMS on the embossing of (d). The assembly of (c) is covered with the PDMS 57.

(f) A PDMS which is poured on a wafer and spin coated thereon is kept at 70 degrees centigrade or above for more than three hours for hardening. (Through this process, a PDMS film 58 is formed having a thickness ranging from 300 μm to 500 μm.)

(g) After $NaHCO_3$ is injected into the assembly of (e), the assembly is covered with the PDMS film 58 of (f).

(h) A PDMS cover 59 wherein a channel through which a cell culture medium flows and a culture surface for a cell (media-line) 61 are engraved is produced by performing the same processes of (d) and (e) using a mask having the shape shown in Fig. 15.

(i) A cell culture unit is completed by covering the

assembly of (g) with the PDMS cover 59 of (h).

In case the cell culture unit is to be used for an adherent cell, a process to induce adsorption of the cell by treating the surface which the cell touches with poly-L-lysine solution over 10 minutes at room temperature may be added after the process of (g).

Although the preferred embodiment is illustrated focusing on a cell culture unit possessing a carbon dioxide supply, a cell culture unit using gas generation in accordance with the fifth preferred embodiment of the present invention may possess an oxygen supply as well as the carbon dioxide supply, in which case the cell culture unit can be used in an environment where an additional oxygen supply is required.

While the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention.

The gases generated by the micropump or the small-sized cell culture unit using gas generation in accordance with the present invention have degree of purity required for subsequent process and reaction. Such gas also provides sufficient pressure and amount to push a liquid sample into a reservoir or a minute channel. When an H_2O_2 solution of 30%(w/w) density is used, oxygen is generated with a volume of more than 100 times larger than that of the H_2O_2 solution. Depending on the amount of catalyst used, the time for generating oxygen can be controlled to range from several minutes to dozens of minutes. Further, because the preferred embodiments of the present invention can be produced cheaply and simply, they can be disposed of after a single use. Furthermore, the preferred embodiments are less dependent on external devices so that they can be integrated easily or to a variety of other LOCs or small devices. Also,

it is advantageous in that by-products are water and oxygen which are environmental friendly and biocompatible. The carbon dioxide generator can be applied to a small-sized cell culture unit, mobility of which is typically limited by problems in the carbon dioxide supply, to commercialize a small-sized portable cell culture unit.

CLAIMS

1. A micropump utilizing gas generation comprising:

a silicon substrate having a reservoir for H_2O_2 solution formed therein;

a SiO_2/Si_3N_4 film formed on the silicon substrate; and

a PDMS combined on the SiO_2/Si_3N_4 film,

wherein the PDMS includes a reservoir for MnO_2 confronting the reservoir for H_2O_2 solution on the other side of the SiO_2/Si_3N_4 film, a sample reservoir connected to the reservoir for MnO_2 through a conduit, a sample injection opening connected to an end of the sample reservoir, and a minute channel leading to an exterior of the micropump from another end of the sample reservoir.

2. A production method of a micropump utilizing gas generation, comprising the steps of:

forming a reservoir for MnO_2, a sample reservoir connected to the reservoir for MnO_2 through a conduit, a sample injection opening connected to an end of the sample reservoir, and a minute channel leading to an exterior of the micropump from another end of the sample reservoir by forming a negative photoresist SU-8 layer and patterning on a silicon substrate;

forming a PDMS on the SU-8 layer;

forming a SiO_2 film and a Si_3N_4 film sequentially on another silicon substrate;

forming a reservoir for H_2O_2 solution by etching the bottom surface of the silicon substrate having the SiO_2 film and the Si_3N_4 film formed thereon;

securing a bottom plate to the bottom of the reservoir for H_2O_2 solution; and

combining the PDMS on the silicon substrate having the reservoir for H_2O_2 solution formed therein after removing the PDMS from the silicon substrate and SU-8 pattern.

3. A micropump utilizing gas generation comprising:

a bottom plate constituting a bottom surface;

a hot-wire formed inside a reservoir on the bottom plate; and

a PDMS combined on the bottom plate,

wherein the PDMS includes the reservoir, a sample reservoir connected to the reservoir through a conduit, a sample injection opening connected to an end of the sample reservoir, and a minute channel leading to an exterior of the micropump from another end of the sample reservoir.

4. The micropump utilizing gas generation of claim 3, further comprising a paraffin layer mixed with MnO_2 powder formed on the hot-wire,

wherein the reservoir reserves H_2O_2 solution.

5. The micropump utilizing gas generation of claim 3, wherein the reservoir reserves $NaHCO_3$ solution.

6. The micropump utilizing gas generation of claim 3, further comprising a water droplet enveloped in a Parafilm arranged on the hot-wire,

wherein the reservoir reserves a mixture of $NaHCO_3$ and $HOC(COOH)(CH_2COOH)_2$.

7. A production method of a micropump utilizing gas generation, comprising the steps of:

forming a hot-wire inside a reservoir on a bottom plate;

combining a PDMS having the reservoir formed therein on the bottom plate; and

combining another PDMS including a sample reservoir connected to the reservoir through a conduit, injection openings respectively connected to each ends of the

reservoir and the sample reservoir, and a minute channel leading to an exterior of the micropump from another end of the sample reservoir on the PDMS having the reservoir formed therein.

8. A cell culture unit utilizing gas generation comprising:

a bottom plate constituting a bottom surface;

a hot-wire formed inside a reservoir for holding $NaHCO_3$ on the bottom plate;

a PDMS including the reservoir formed by combining the PDMS on the bottom surface and an air supply line connected to the reservoir through a conduit;

a thin permeable PDMS film arranged on the PDMS; and

a PDMS cover being combined on the PDMS film and having an engraved media-line confronting the air supply line on the other side of the PDMS film.

FIG. 1

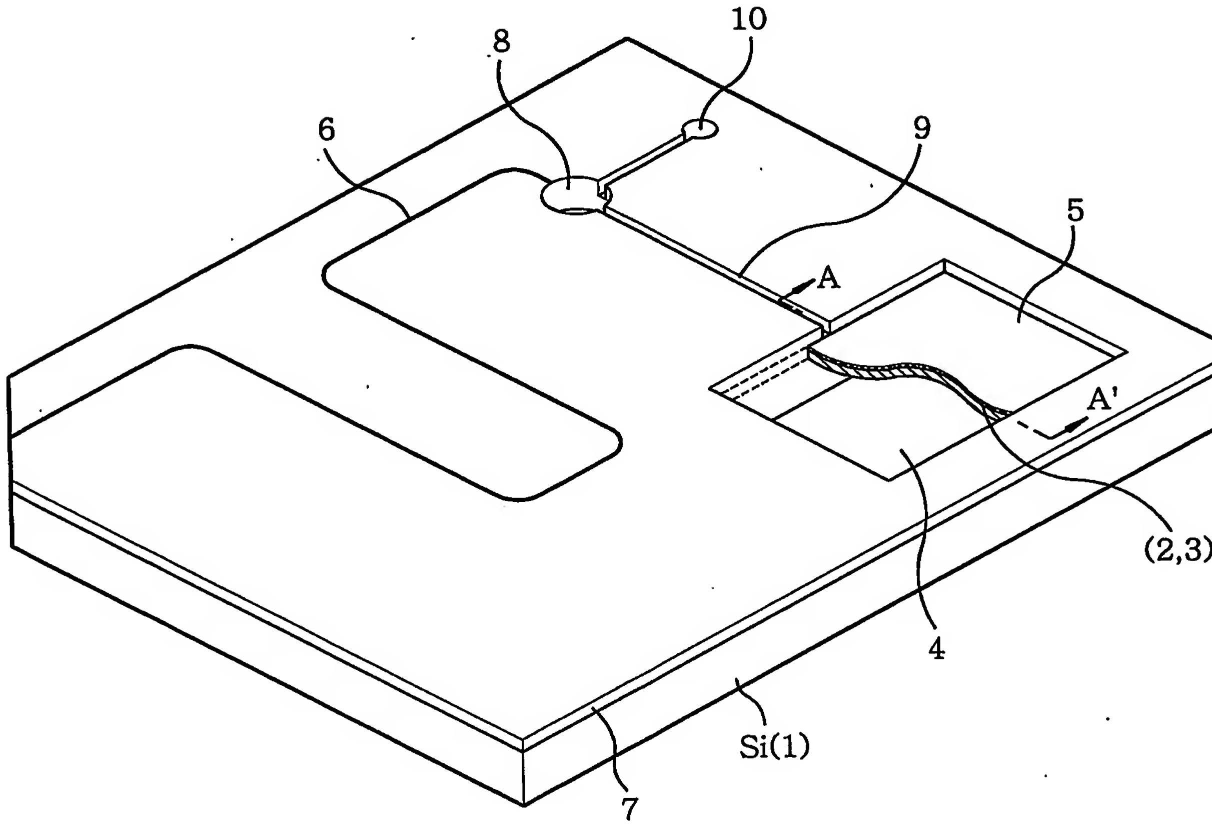


FIG. 2

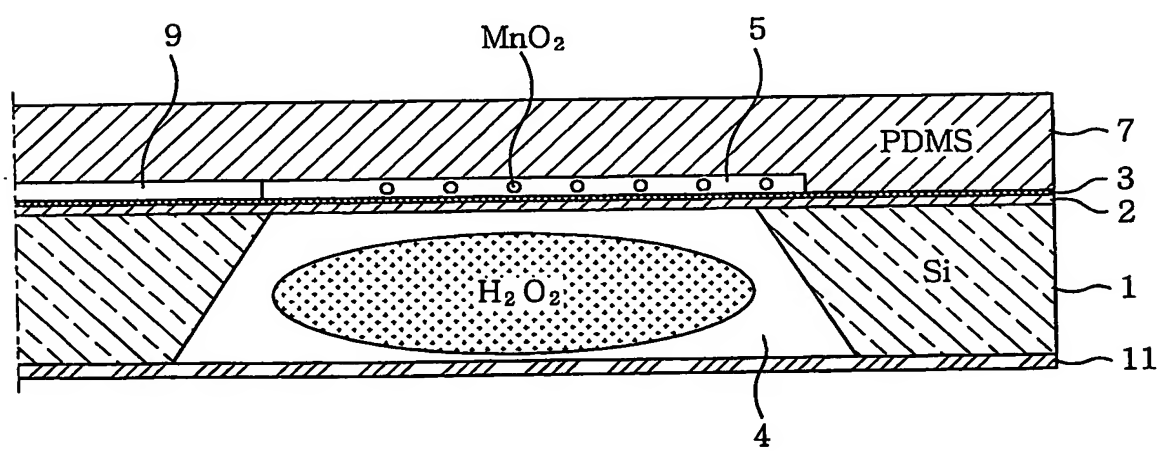


FIG.3A

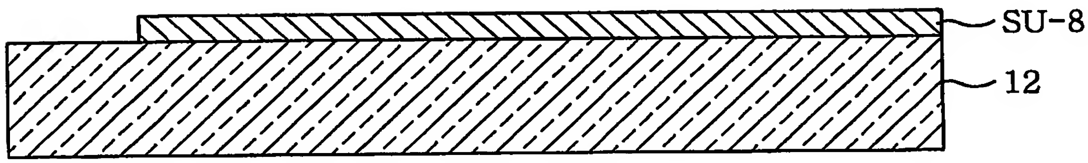


FIG.3B

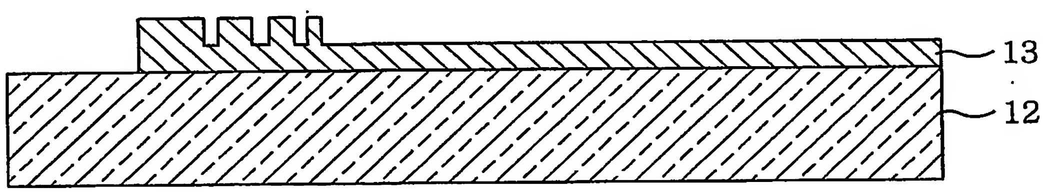


FIG.3C

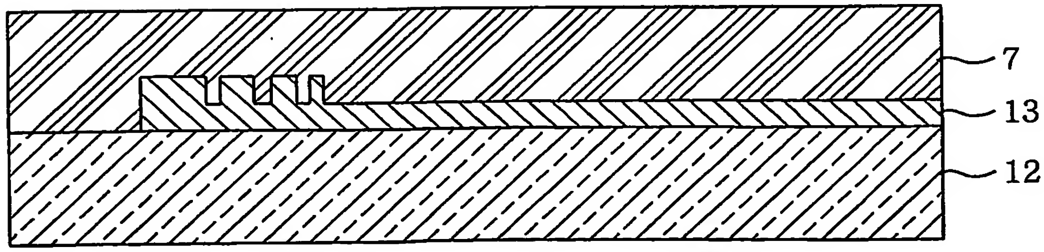


FIG.3D

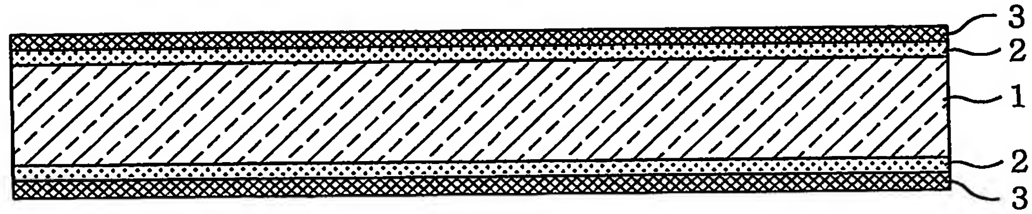


FIG.3E

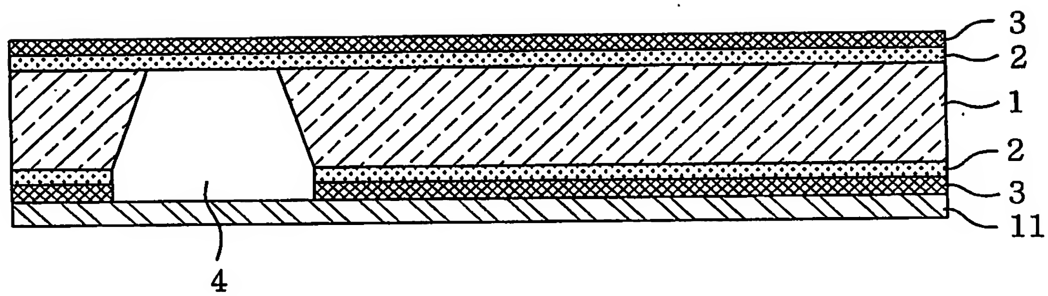


FIG.3F

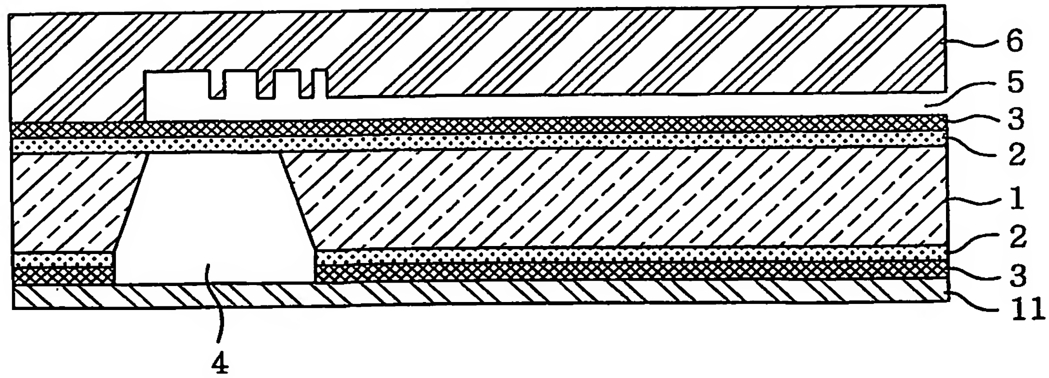


FIG. 4

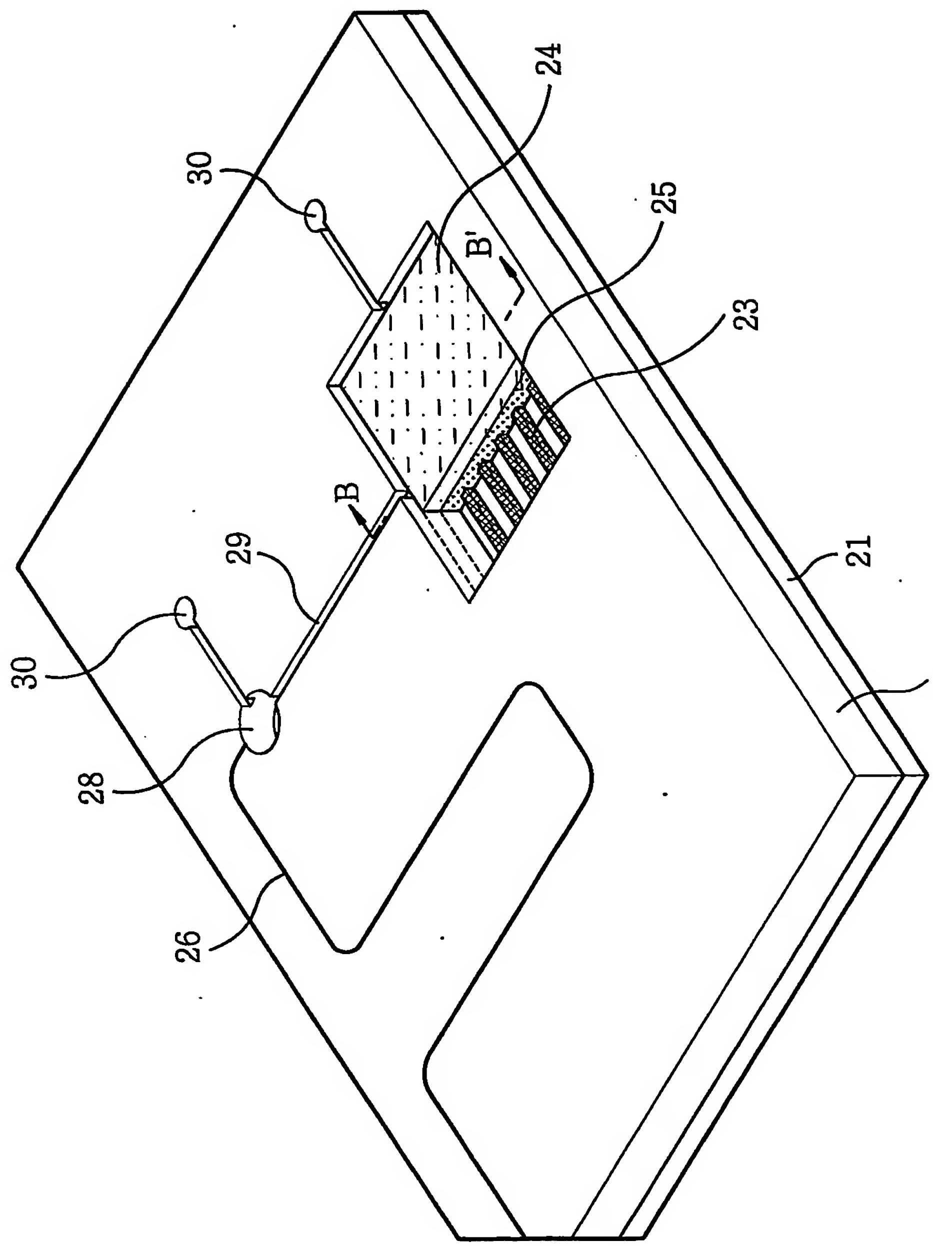


FIG.5

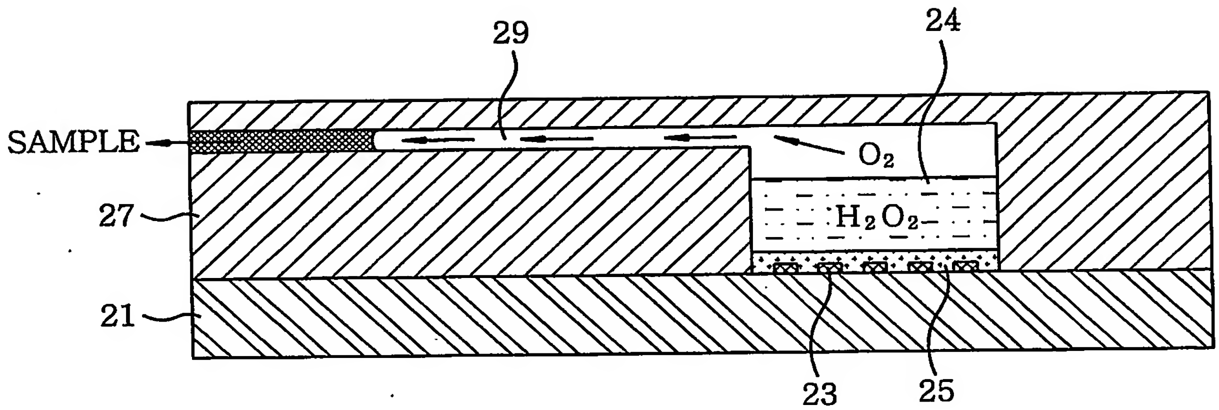


FIG.6A

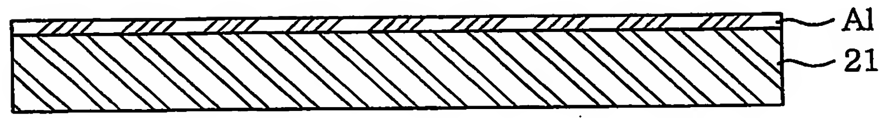


FIG.6B

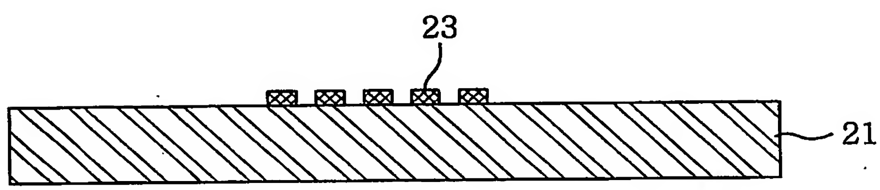


FIG.6C

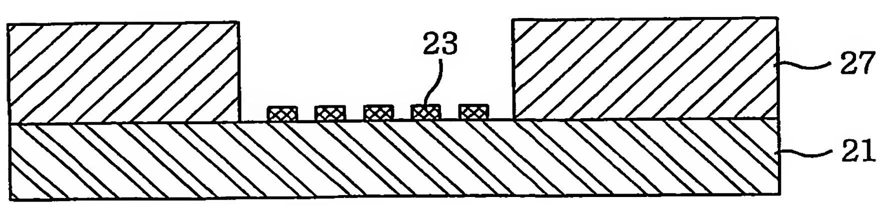


FIG.6D

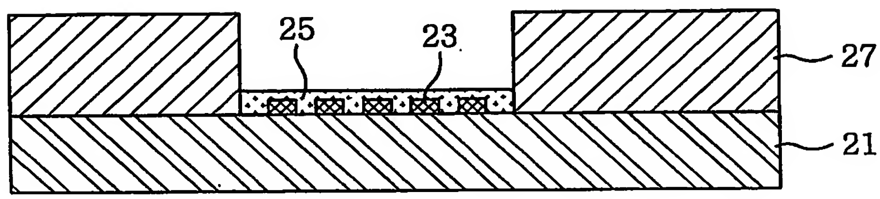


FIG.6E

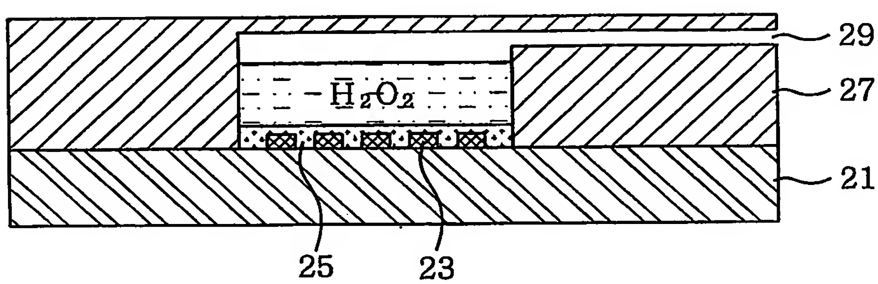


FIG.7

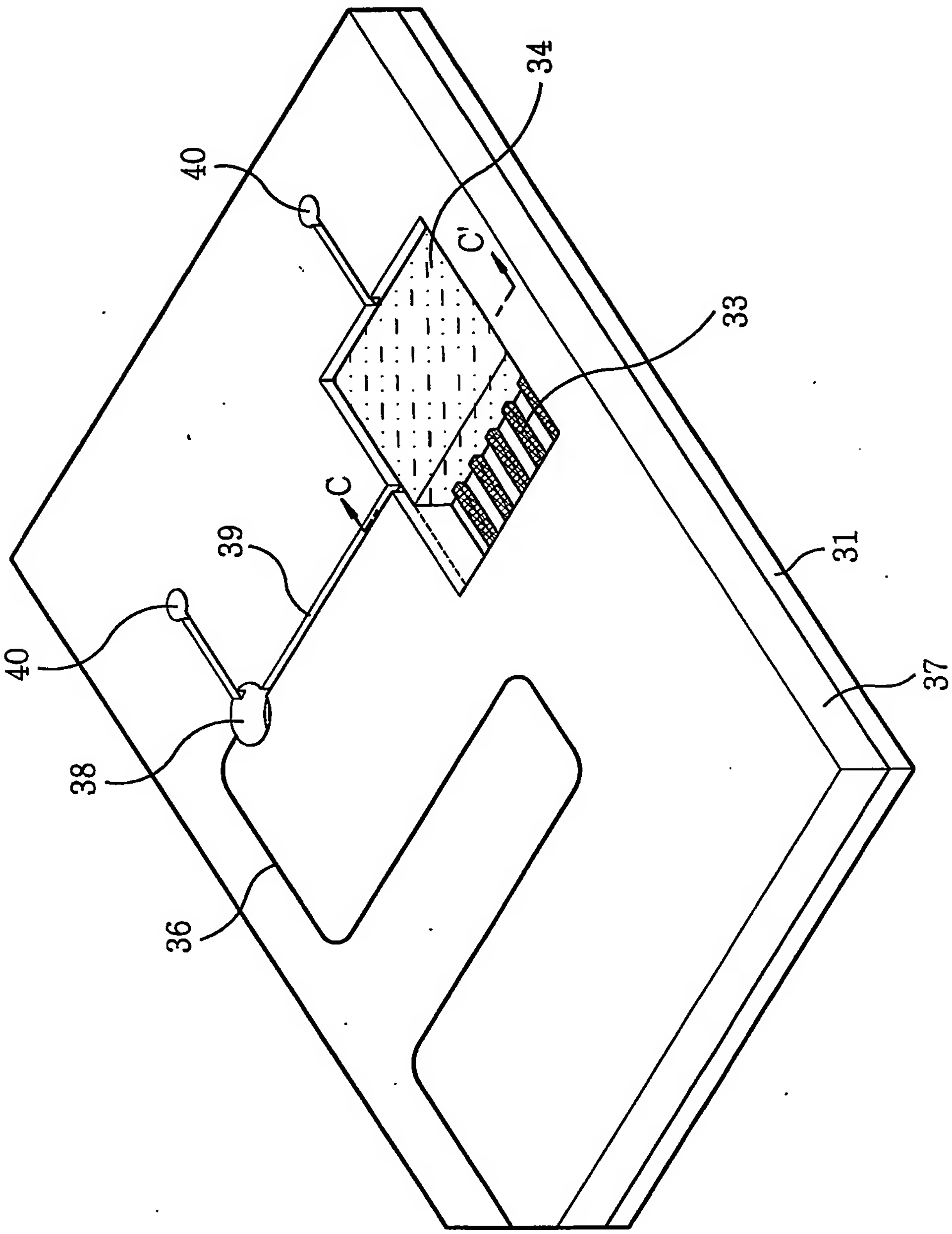


FIG.8

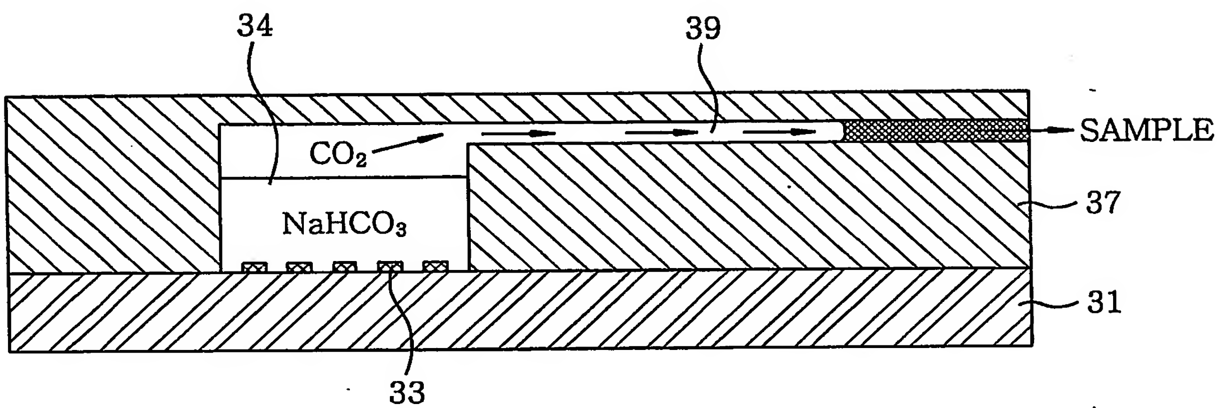


FIG.9

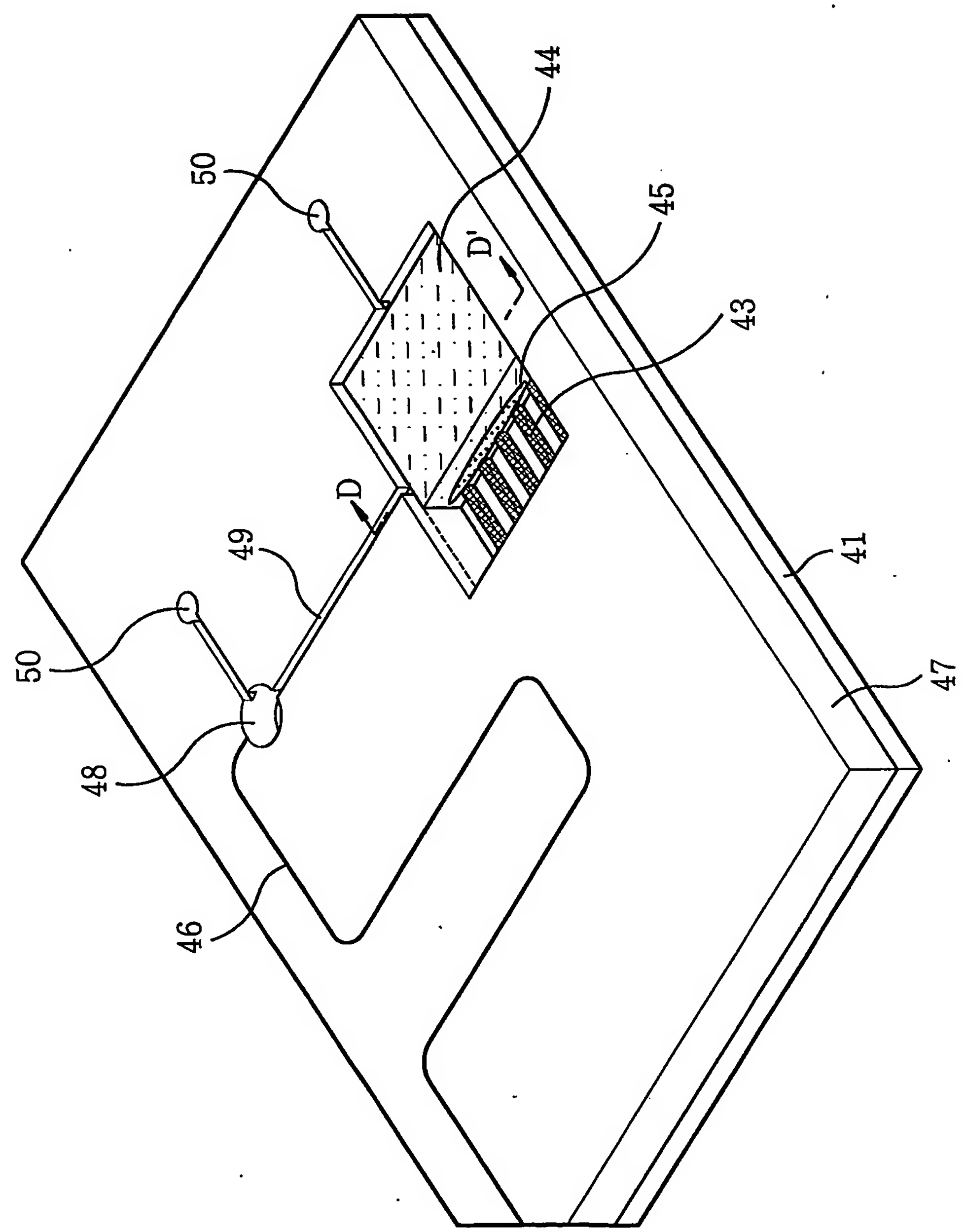


FIG. 10

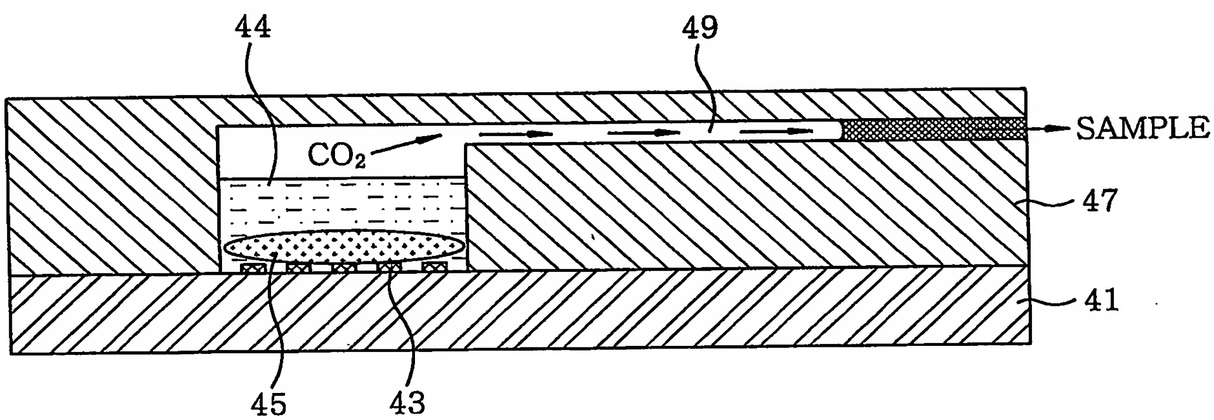


FIG. 11

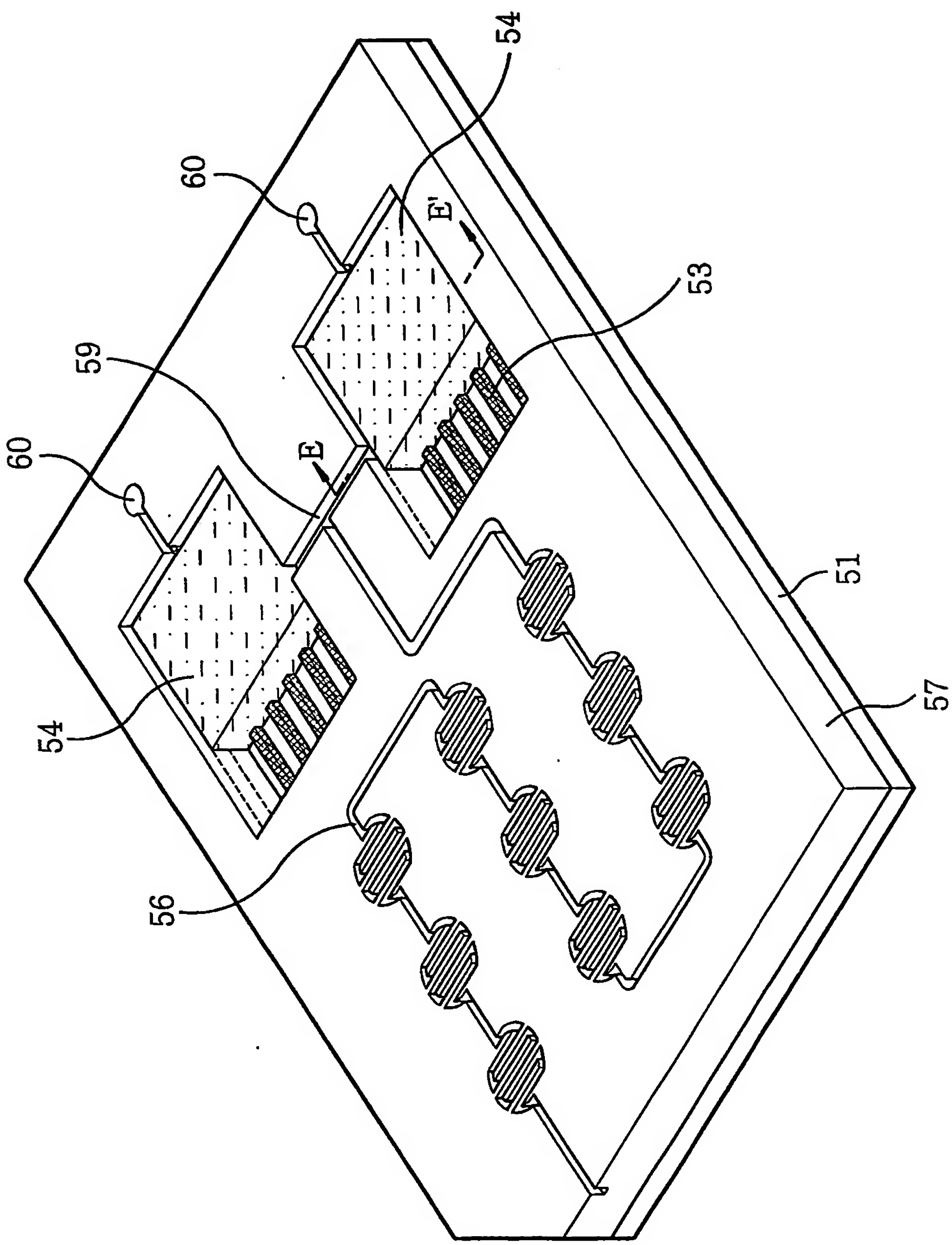


FIG.12

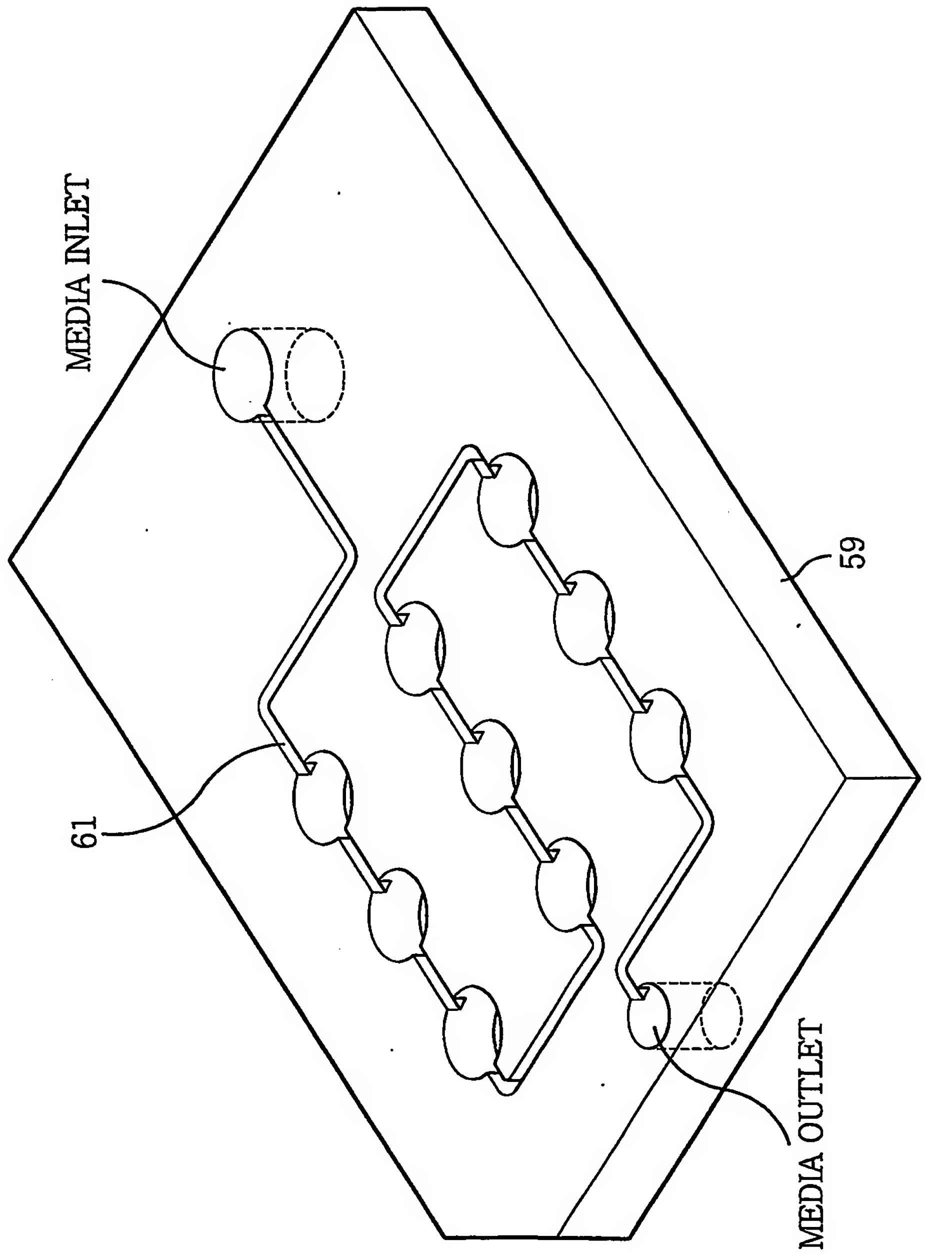


FIG. 13

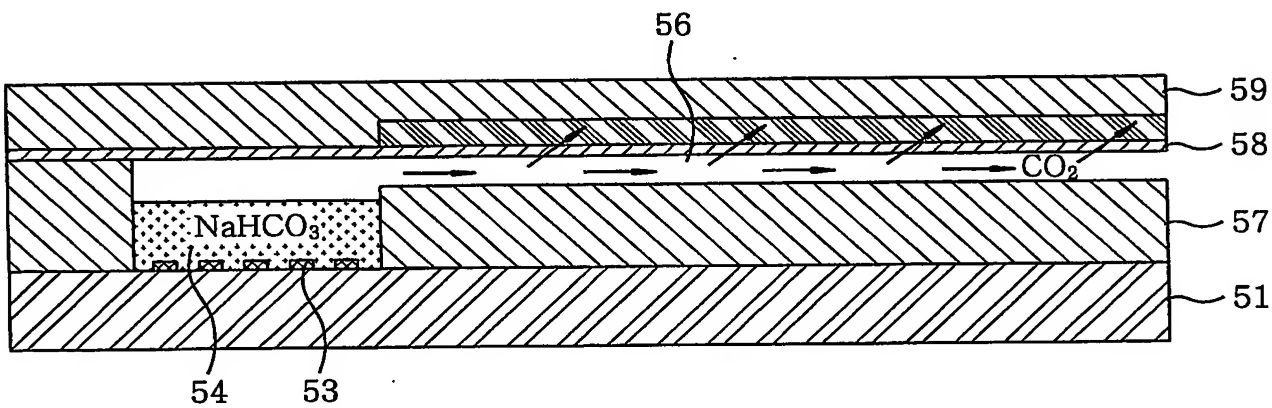


FIG. 14

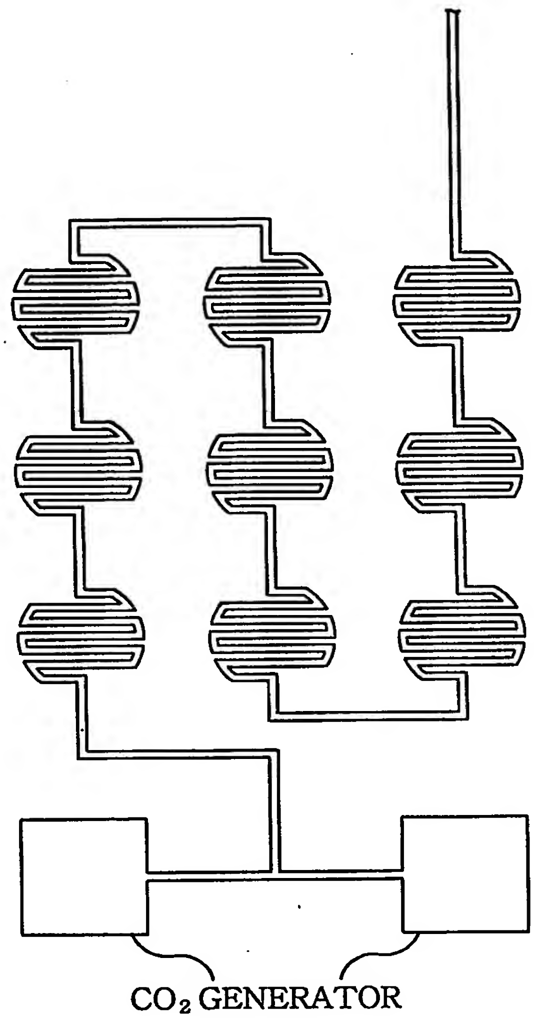
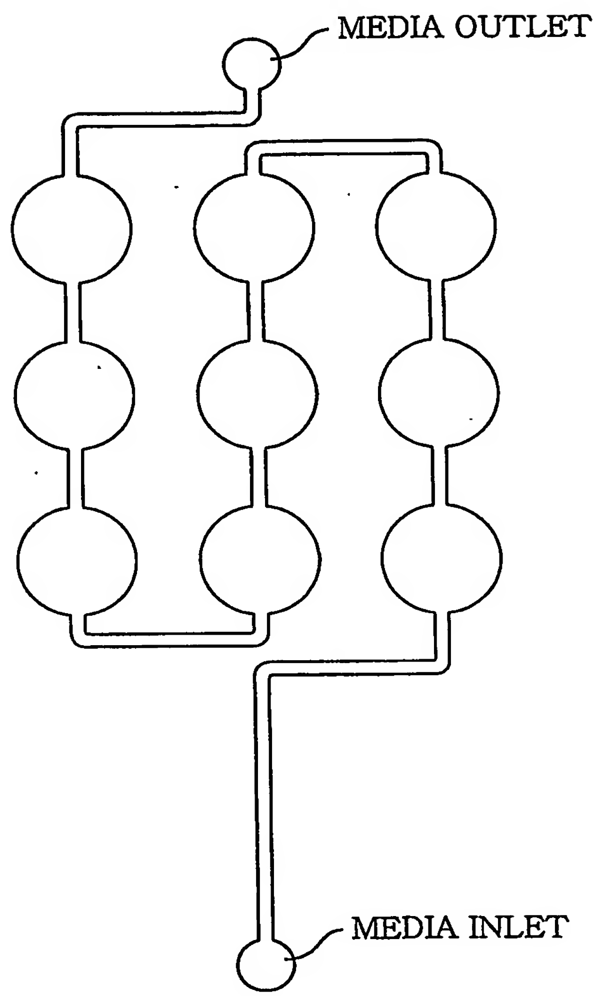


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2003/002606

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 B81B 7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 B81B 7/02, B81B 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1983

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

eKIPASS " lab-on-a-chip", "micro pump", "channel", "gas"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 2003-0070954 A(Electronics and Telecommunications Research Institute) 03 Sep 2003 See the entire document	1,2
A	JP 08-118632 A(FUJITSU CORP.) 14 May 1996 See the abstract and Fig.1	1
A	JP 13-260094 A(SUMITOMO METAL CORP.) 26 Sep 2001 See the entire document	2

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
02 MARCH 2004 (02.03.2004)	02 MARCH 2004 (02.03.2004)

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JEONG, Ho Geun

Telephone No. 82-42-481-8143

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2003/002606

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 2003-0070954 A	03.09.2003	NONE	
JP 08-118632 A	14.03.1996	NONE	
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